SUN-SPOT PERIODS IN METEOROLOGY.

In the Meteorologische Zeitschrift for October, 1903, Vol. XX, p. 478, Dr. A. Nippoldt, jr., states that the numerous researches published by Prof. J. N. Lockyer and his son, Dr. W. J. S. Lockyer, during the past twenty years, have developed new ideas concerning the relation of sun spots to terrestrial magnetism. The latest memoir, Proceedings of the Royal Society, 1903, vol. 71, pp. 244–250, maintains that it is the solar protuberances and solar faculæ, not the solar spots, that appear to vary with the important magnetic disturbances. The great terrestrial disturbances, or the exceptional disturbances, decrease in proportion as the solar phenomena occur in higher latitudes, namely, more distant from the solar equator, whereas the regular periodic variations in terrestrial magnetism seem to be more especially influenced by the activities near the solar equator. Lockyer explains this on the assumption that the increase of faculæ and protuberances causes an increased variation in the energies on the sun's surface, and, since the total area of faculæ and protuberances is much larger than the area covered by the spots, therefore it would seem plausible that the former should have a greater influence than the latter. The occurrence of spots is, therefore, an unimportant concomitant of the condition that causes magnetic disturbance.

Dr. Nippoldt adds that Marchand had also endeavored to show that the faculæ are the effective or productive solar phenomena. (See the Proceedings of the International Meteorological Congress, Paris, 1900.) These views of Lockyer are supported by the view adopted by other investigators, to the effect that the gaseous flames or protuberances of the sun cause a transportation of elastic energy toward the earth, and thus determine the variations of our own magnetism, electricity, and auroras. From all this it seems to follow that the sun spots are by themselves very poor representatives of the actual effective forces of disturbance.

In the American Journal of Science and Arts, November, 1870, 2d series, Vol. L, p. 345, the present Editor of the MONTHLY WEATHER REVIEW published the results of one of his earliest investigations on the connection between terrestrial temperature and solar spots. Among other things he made a special study of temperatures observed on the Hohenpeissenberg, as published in the supplementary Vol. I of the Annals of the Munich Observatory. This series extends from 1792–1850. The thermometers were observed daily at 7 a. m., 2 and 9 p. m. The annual mean temperatures deduced from all the observations was compared with the table of relative sun-spot numbers given by Wolf, and it was shown that a change of 100 in the sun-spot number (which is very closely the range between the years of least and years of greatest spot frequency) corresponds to a change of 0.789° R., or 0.986° C., in the mean annual temperature. A similar comparison between the sun-spot curve and the temperatures observed at 2 p. m. showed that a change of 100 in the spot number corresponds to a change of 0.801° R., or 1.001° C., in the observed temperature. The outstanding discrepancies of the individual annual means were so greatly reduced by making allowance for this sun-spot influence that the so-called probable error of these values was only 0.204° R. in the first case and 0.221° R. in the second. There was, therefore, every reason to believe in the reality of a general variation in the earth's mean annual temperature and in the solar radiation running parallel with the variations of the sun spots and having a range of 0.8° R., or 1.0° C., for a total range of 100 in Wolf's relative sun-spot numbers. The larger the number of spots the smaller the mean annual temperature. The author also found "plain indications of a period of about 50 or 55 years' duration, probably identical with five sun-spot periods or Wolf's 56-year period." He adds that "the solar spots are but an imperfect index to the periodic changes in the solar radiation, these changes being apparently more intimately and directly connected with tides in the cool atmosphere surrounding the solar photosphere." Further investigation of this subject was delayed by the Editor's removal from Cincinnati to Washington, and the investigation was subsequently carried out more elaborately by Dr. Koeppen, of the Seewarte at Hamburg, who was able to show that an increase of sun-spot numbers coincided with a prompt diminution of temperature in the equatorial regions, but with more complex effects as we proceed toward either pole. According to Koeppen, an increase of 100 in Wolf's sun-spot numbers corresponds to a decrease of 0.54° C. in the mean annual temperature of the whole tropical zone.

On page 263 of the Meteorologische Zeitschrift, August, 1873, Koeppen says:

> The two phenomena, sun spots and tropical temperatures, are evidently connected, but what the nature of this connection is can not at present be definitely determined. But it is clear that the sun spots do not act as a partial eclipse by darkening one portion of the sun's disk, while the remaining portion continues to radiate as before. Since the temperature of the earth's surface is a summation result of solar radiation, therefore the change in this latter should necessarily occur later than the change in the intensity of radiation; but as the number of sun spots and probably also the total area of the spots attains a minimum and maximum after the corresponding maximum and minimum in the temperature of the tropical stations. * * * It appears to me that the data here presented justify the assumption that the temperature of the sun's surface, for some unknown reason, is highest one or two years before the minimum of sun spots.

In the MONTHLY WEATHER REVIEW for August, 1903, pages 371–373, we gave the results of the most recent publication on this subject by Professor Angot, according to whom the probability is 7 to 1 that an increase of 100 in the relative sun-spot number is accompanied by a diminution of 0.33° C. in a mean annual temperature of stations within the Tropics. This is not very different from the results obtained by Koeppen for tropical regions, and by the present Editor for Hohenpeissenberg. Now the irregularities in our mean annual temperatures must be considered as being due partly to variations in the heat received from solar radiation, and partly to the irregularities of wind, cloud, rain, fog, etc., and it becomes desirable to obtain a clear idea of the relative importance of these solar and terrestrial sources of irregularities. This may be done by the following method: On page 372 of the August REVIEW Angot gives the details of his calculations for the station at Camp Jacob on the island of Guadeloupe. He finds that the probable departure of any annual mean daily temperature from the general average is $\pm$ 0.20° C. when all sources of irregularity have full play. But if the periodic irregularities apparently due to the sun spots are allowed for, then the remaining or terrestrial sources of uncertainty produce a probable departure of only $\pm$ 0.06 °C. In other words the variations due to terrestrial atmospheric irregularities represent $\pm$ 0.06° C.; those due to the solar variations represent $\pm$ 0.19° C., and those due to both causes combined amount to $\pm$ 0.20° C. The relative importance of the solar and terrestrial irregularities is therefore as 361 to 36, or 10 to 1.

The other tropical stations quoted by Angot give smaller values for the influence of the solar variations. The long series of records at stations beyond the Tropics also show that there the terrestrial influences are greater. Indeed, Koeppen found that in the North Temperate Zone the regular changes of atmospheric circulation and cloudiness completely mask the variations of temperature in our atmosphere that appear to be due to the influence of solar variations. Our own computation for Hohenpeissenberg, 1792–1850, as above quoted, shows that the variation of any annual mean daily temperature from the average of fifty-three years is $\pm$0.449° R. when terrestrial and solar variations are included, but it becomes $\pm$0.430° R. when sun-spot variations are excluded and terrestrial only remain. This shows that at this location the sun-spot influence is represented by $\pm\sqrt{(0.449)^2-(0.430)^2}=\pm 0.129°$ R., whence we infer that the solar influences are to the terrestrial influences as $(0.129)^2$ is to $(0.430)^2$ or as 0.0167 is to 0.1849, or very nearly as 1 to 11. A similar computation is still more instructive if we use not the mean daily temperatures for each year, but the annual means of the temperatures observed at 2 p. m., which may be supposed to show the direct heating power of the sun with especial clearness. In this case the variation of any annual mean is $\pm 0.489°$ R. when both terrestrial and solar variations are included, but $\pm 0.465°$ R. when sun-spot variations are excluded, thus leaving $\pm 0.151°$ R. as the result of the sun-spot disturbances, and making the midday or maximum solar influence to be to the terrestrial influences very nearly as $(0.151)^2$ is to $(0.465)^2$ or as 0.0229 to 0.2162 or as 1 to 10.

THE NOISES MADE BY PROJECTILES AND METEORS.

The existence of the atmosphere at great heights above the ground is usually said to be demonstrated by the fact that meteors or shooting stars are heated by the compression of the air in front of them as they rush along at the rate of from 10 to 30 miles per second. The heat is sufficient to burn off the surface of the meteor, making a bright light and oftentimes leaving a trail behind. The altitudes of such meteors vary between 10 and 100 miles, as shown by satisfactory observations for parallax, made by observers many miles apart.

At this great altitude the air is probably very rare; it may even be questioned whether it is dense enough to produce any great heating effect at an altitude of 100 miles. We are inclined to suspect that there may be clouds of fine solid particles revolving about the earth in this region rather than a gaseous atmosphere. The zodiacal light may be explained as the light from either a gaseous ring or a stream of particles as fine as sand surrounding the earth. A gas under no external pressure will not stay in one location; it either diffuses or else becomes a ring of independent particles.

There has been some discussion as to the ultimate origin of the noise that proceeds from a large meteor as it rushes through the atmosphere. Most observers describe the noise as similar to that of the discharge of a cannon, but followed by a long rumble like that of thunder or perhaps the rattle of musketry. The meteor moves so rapidly that we have, as it were, a straight line many miles long and a hundred miles distant from the observer which becomes the source of sound waves starting almost simultaneously from the whole length of the path. The concentration of these waves at the observer's station explains the explosive noise and the subsequent rattling, but what makes the original violent sound waves? There are four ideas as to this, all of which may be true:

1.—The meteor strikes the air so violently as to produce the same effect as when it strikes a liquid or a solid.

2.—The rapid movement of the meteor leaves a long vacuous trail, into which the surrounding air rushes and the impact of air on air starts the sound wave.

3.—The meteor revolving rapidly on its axis, striking the air a myriad of times on all sides and in all directions, produces a rapid succession of waves.

4.—The meteor is so heated by the compression of air in front that it burns and cracks, and there is a continuous sputtering as its surface particles burn up, split off, and flow away.

What are the phenomena of sound observed a short distance from the path of a projectile when going past the observer at the greatest possible speed? Can any plausible explanation of the noises that attend meteors be given, taking into consideration the fact that the greater part of their path is at such a high elevation that atmospheric pressure or density is not the thousandth part of what prevails at the earth's surface? I have heard the whistling of bullets as they passed over my head, but these do not move much faster than the waves of sound, whereas a meteor frequently moves 20 miles per second, or 100 times the velocity of sound and the noises starting simultaneously from the 20 miles of its path that is nearest to the observer, must reach his ear as one concussion.

On this subject Prof. Philip A. Alger of the United States Naval Academy, of Annapolis, Md., writes as follows:

Although I have witnessed the firing of thousands of rounds from all sorts of guns, I can not distinctly recall the sound made by projectiles in flight as heard by one near the guns. I suppose the attention is distracted by the louder sound of the discharge; and I have never been near the path of a projectile and at the same time far from the gun itself. The sound made by a piece of shell, such as often glances from an armor plate and flies to a considerable distance, is like a shrill whistle, as I remember it; and the sound made by a large shell which for some reason has not sufficient rotation to travel smoothly point first and therefore wabbles and finally tumbles end over end, is as Lieutenant Strauss describes it.

Many of the projectiles to which the inclosed letters refer have velocities as high as 2900 and 3000 feet per second.

As far as meteors are concerned, it seems to me unlikely that their impact upon the atmosphere can make a sound in the way that would happen if they struck a solid or liquid. There can be no line of demarcation between the atmosphere and surrounding space, it seems to me, and the meteor will pass by insensible gradations from a vacuum into air of measurable density.

I imagine the other three causes you name, and especially the rushing of the air into the vacuum formed in the meteor's path, are the true explanations.

Lieut. A. C. Diffenbach writes:

In reply to yours of the 4th, the consensus of opinion seems to be that the nearest approach to description of the noise of the shell in flight is that of a railway train when a little distance off, so as not to hear the clatter of the rails, but simply a roar. It is very difficult to describe. It seems a little bit like some one holding a tube to your ear and giving a prolonged shout or roar into it. Of course, it has the fading away due to distance.

Lieut. John Strauss writes:

While in the office at the Naval Proving Ground I have, of course, frequently heard the sound of passing projectiles. As the disturbed air wave reaches you, a sound is made that is about half way between a boom and a crack, and then a moment later comes the boom of the discharge. The crack is almost as loud as the boom and perhaps a little more annoying.

When a large shot tumbles, the rumble sounds to those near the trajectory like that of a railroad train.

CLIMATE AND MANKIND.

Prof. R. E. Dodge, of Teachers' College, Columbia University, has written a pamphlet of 18 pages, entitled a "Syllabus of a Course of Six Lectures on Climate and Mankind."

1. Climate and Mankind: Introduction. 2. Life in Deserts. 3. Life in Temperate Lands. 4. Life in Tropical Forests. 5. Mountains and People. 6. Plains and People.

As many of the readers of the MONTHLY WEATHER REVIEW are engaged in lecturing and teaching on these subjects, we can not do better than to recommend that they send ten cents to the Teachers' College of Columbia University, New York City, and obtain a copy of this syllabus, as it certainly contains many excellent suggestions for the use of teachers of geography, among whom Professor Dodge is a leading authority.

RELIABILITY OF HIGH WIND RECORDS.

In reply to a question as to the highest recorded velocity and pressure of the wind, it may be said that it has long been recognized that the devices that were used in 1870 and earlier for measuring the force of the wind by means of the pressure on moving plates, etc., are likely to yield quite inaccurate results, especially with respect to the maximum gusts. This is owing to the unavoidable effects of the inertia of the moving